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PREPARING CONTRACTOR
REPORTS FOR NASA:

DATA
PRESENTATION

NASA

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DATA PRESENTATION

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NASA Report Preparation Series

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NASA SP-7012 The International System of Units

PREFACE

The heart of any scientific or technical report is the data it presents. This booklet contains basic suggestions for presenting both graphic and tabular data in the context of a report that receives distribution within the general scientific community. Mechanical and format suggestions are intended to allow authors broad scope in devising presentations, yet at the same time to insure clarity and reproducibility.

INTRODUCTION

On the surface there seem to be three methods of presenting data: discussion; tabulations; or graphs. Actually, tabulations or graphs used without an explanation are usually meaningless to the reader. You must tell him how you obtained your data, how you processed this information, how you arranged it and why--and most important--what it means in relation to your subject. So the three methods really boil down to only two: graphs or tables. Happily the choice is not mutually exclusive and normally your only moral obligation is not to present identical data in both tabular and graphic form. Your choice will depend upon the complex relationships you are trying to convey to the reader.

Consider tables first, primarily because the most effective graphs are prepared from carefully designed tables. Obviously you can pack more information in a given area by using tables, but you will also want to consider some other equally important factors:

1. Can I organize these data into a table that will convey my meaning to the reader?

2. Does my reader need (or want) a detailed numerical presentation?

If you can answer YES to both of these questions, tabulate! But if there is a doubt with either, then consider:

3. Can I condense or summarize sufficiently to get my point across more quickly and effectively?

A good affirmative on No. 3 will sometimes lead you to the use of an appendix containing the voluminous detailed data for the special reader who needs to know what really happened. But you

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may ask a few more questions to determine how the condensation of data can best be accomplished:

4. Are the detailed numerical <u>values</u> more important to understanding the report than numerical <u>relationships</u>?

5. Are the relationships of the values to each other more enlightening than the precise values?

If your answer is yes to No. 4, you will probably want to stay with tables, but a yes answer to No. 5 is a strong indication that you had better go the graph route.

Supporting your decision to use graphs is the fact that some comparisons of values and sets of values that demonstrate trends might be well suited to tabulation, but the same trends and inter-relationships become much more apparent and meaningful when the data are presented in the form of graphs. Graphs provide direct, easily grasped visualization of numerical data. They should be regarded as a desirable alternative to be used whenever they will help make complicated relationships clear to the reader.

The choice between tables and graphs is up to you. To verify your choice again consider these facts:

- Does my reader want (or need) the numbers?

- Can I tell the story more effectively with a visual device?

- Can I devise a graphic summary of voluminous graphic and/or tabular data for use in the body of the report and carry the complete data in an appendix?

TABLES IN GENERAL

Let's get down to the nuts and bolts of building, presenting, and talking about good tabular data. Before you begin to nod over lists of "thou shalts" and "thou shalt nots", let's take a good look at a few general things about tables.

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First of all a table is <u>functional</u>--it has a specific job to do, and is designed at the outset to accomplish that purpose. For this reason, it is worthwhile to carefully cull all material (no matter how vital) that does not have some meaning for the reader of the table. Dates often fall into this category.

Not every one has your neat, logical mind; some readers have difficulty sorting significant items into any semblance of order. It's up to you to predigest data into logical and parallel groupings so that the reader quickly grasps their significance and can follow your narrative more easily. Naturally this requires some effort on your part, but the things you do can be summarized in this manner:

- Group information logically.

- Use comparable units of measure.

- Make related tables as nearly parallel as possible.

- Discuss each table and its significance in the text.

- Relate tables, text, and illustrations by use of captions and discussion; always use consistent terminology and standard abbreviations.

THE ORGANIZATION OF A TABLE

A well-conceived table is organized in a fairly obvious and straightforward manner. Table technicians, anxious to demonstrate their expertise, have given names to the most common features of tables. Naturally, not all tables will have the features identified in the following paragraphs, but this little exercise in table technology may aid you in simplifying the complex tables that sometimes race through technical reports.

Of course any well-constructed table has a title--and since many tables that look alike are not alike, the title is a distinguishing factor and should be quite distinctive. In a highly organized

world, that which is unique also has a number. (Look in your wallet.) A table is properly identified by a title and a number.

TABLE 17. THE TITLE OF THE TABLE GOES IN THIS SPACE

Headings appear at the top of the table. They may be either simple or complex according to the need, but are always descriptive.

The stub column ordinarily appears at the far left and is used to help identify rows of data entered in the columns.

Not unexpectedly, the foot of the table is reserved for footnotes.

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Headings

What a table can and can't do is largely determined by the nature of the variables labeled in the headings. Select these carefully, paying great attention to such things as:

● Necessity--If nearly every value under a particular heading is the same, why not footnote the variants? The nearly constant factor can be noted in the title or subtitle. Not only do you save column space, but often make the reader's task less formidable.

TAFLE 19. CONSTANT TEMPERATURE TEST   TABLE 19. TESTING AT 90°F OF MATER

Material	Temp °F
	90
	90
	90
	89
	90
	90
	90
	90

Material

*Tested at 89°F

● Suitability--Do you find you have to "change horses" or alter column headings to tell your story? Then consider the use of more columns, more general headings, omission of extraneous matter, or breaking the table into two separate presentations.

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● Function--Does the heading adequately describe the variable below? Letter symbols are not adequate identification in many cases, and should be supported and explained by use of verbal equivalents. (You'll have to judge your audience here.) In all cases, the unit of measure should be noted in the heading. Consistency is vital here, because reader confusion could lead to total misinterpretation of your hard-won data.

Test	w	p	p_t	R

Test	Mass flow rate, w, kg/sec	Static pressure, p, newton/m^2	Total pressure, p_t, newton/m^2	Radius, R, cm

Now that we have ground rules for choosing headings, let's look at the exceptions and problem areas that prove the rule. There are perfectly good tables that do not use headings. Usually they are quite simple and self-explanatory. From this, we can derive a simple rule--ANY element can be left out IF the resulting table communicates as well (or better) without that element.

```
Cryogenic liner . . . . . . . . .  0.63 lb

Insulation Assembly
   Top dome  . . . . . . . . . . . .  1.26
   Cylinder section  . . . . . . .  3.64
   Bottom dome . . . . . . . . . .  1.17
      Subtotal  . . . . . . . . . .  6.70
```

Headings are not always the simple matter illustrated in the preceding pages. For example, here are some rather complex arrangements that are possible without violating any of the rules:

The Stub

Constants determine the basic arrangement or order of presentation in any table. As a general rule, constants are entered in the stub, and serve to introduce and control the columnar entries (variables) under the headings.

Here again, your neat and logical approach must be brought to bear against the problem of devising a logical sequence. Arrangement here will gain or lose readers, and there are many avenues open to you in setting up a meaningful order. You may find that the order in which you gathered data means nothing to your reader--he couldn't care less how--he wants to know what the results are. Some arrangements you can consider when organizing stub entries are:

- Time sequences (order of gathering data)
- By materials or general classes
- By test conditions or procedures
- By observed phenomena
- By source
- Combinations of the above

When you evaluate newly prepared draft tables of data, you may find that the headings really belong in the stub. This happens frequently, so it is a worthwhile mental exercise to reverse the two experimentally. It often leads to great simplification.

Type Test	Sample Number				
	1	2	3	4	5
ununun					
ununun					
ununun					
ununun					
ununun					

Sample Number	Type Test				
	IIII	IIII	IIII	IIII	IIII
1					
2					
3					
4					
5					

Organizing stub entries sometimes leads to problems in format and presentation. Several suggested solutions for complex format presentations are shown in the following examples:

OUTLINE FORM

HEADING FORM

TOTAL AND AVERAGE RUN IN

Entries

All the foregoing was simply to provide you with a framework to organize and support the columnar entries. From here on, it's mostly up to you, but there are few rules that might help out when the going gets sticky.

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For example, suppose there are no meaningful entries in a particular column. If the table is not a part of a directly comparable series, it's best to throw the column out. But if this occurs in only one of the series of tables designed to be directly compared, one against the other, you'll probably want to retain the blank column.

In other instances, you may find the entries change character halfway down the column, or must be extensively footnoted. This, unfortunately calls for reevaluation of the headings, making sure that they really describe the columnar entries.

Footnotes

When complex data are presented, footnotes are indispensable. You should carefully consider all information relegated to footnotes, however, or the footnotes will overwhelm the rest of the table, making it difficult to interpret.

Footnotes legitimately contain statements of special conditions relating to an entry or class of entries, or other qualifying verbal information, such as identification of an outside data source. Additional tabulations should not be shown as a footnote, nor should the footnotes be used to discuss the significance of the data presented in the table.

Use superscripted letters or asterisks to identify footnotes, as readers often mistake superscripted numerals for exponents.

USE OF TABLES

No reader wants to plow through scores of pages of test procedures, mathematical derivations, etc., only to find at the end he is told to "see Tables 1 through 89 for test results." Discussion of the significant features of all tables presented is a "must" for your text. Summarization in either graphic or tabular form for the more extensive tabulations is a little extra trouble for you, but is a real aid to your busy reader. Perhaps you will want to show significant values from selected periods or tests, or meaningful trends sampled from several pages of slowly undulating values.

Some investigators find themselves with bushels of tabulations--all of which are useful and meaningful to the studious analyst--but feel the reader prefers to analyze and infer his own conclusions rather than accept the investigator's. Granted, there are some such in any report's readership, but chances are that many of your readers will be from another scientific discipline, or a separate if related field, or management.

This is particularly true in the space sciences where information from many once-isolated, specialized disciplines must converge and be assimilated by a single project manager. The solution is to satisfy all segments of the readership by including analyzed, summarized discussions and tabulations that depict the scope of the data and important trends, and including as appendixes organized, detailed, lucid, logical displays of important data for the reader who "rolls his own".
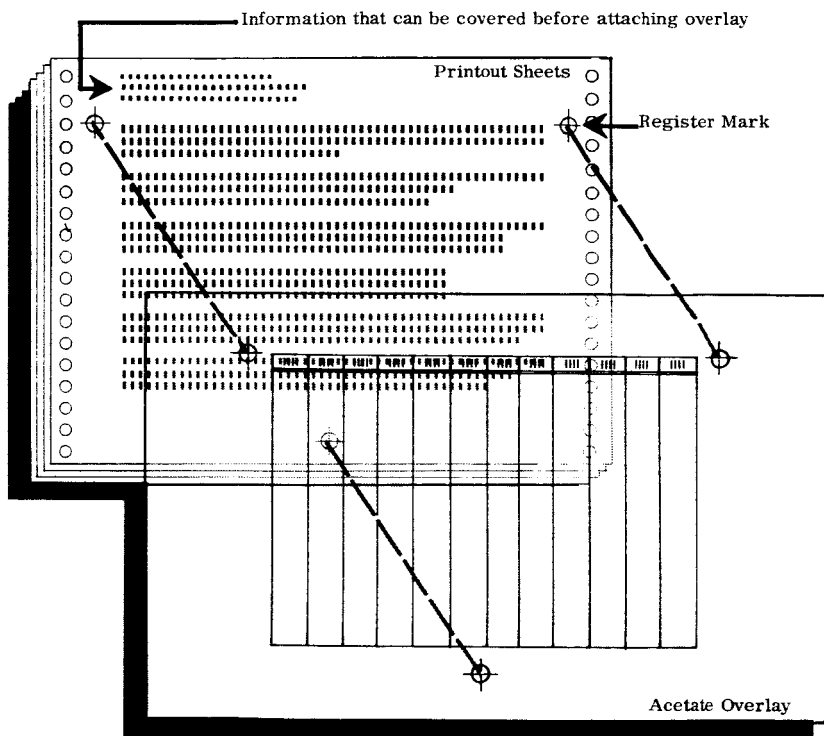
Computer Printout Tables

More and more often important segments of a research effort are expressed as reams of computer-printout data. These tabulations are sometimes needed in reports, but are generally frowned upon by quality-conscious publications groups. An alert report author can get around these objections by observing a few rules for making printout data mean something for the ultimate consumer-- the reader.

First of all, don't use any more printout than absolutely necessary. It is difficult to read in the printed version, and sometimes completely illegible in later facsimile copies. (You would be surprised how many of your readers have to work from microfilm and facsimile copies.)

Plan to have the printer programed to print headings above each column or each page-size increment of the printout. Make sure the operator knows the printout will be camera copied so he can use a fresh black ribbon and proper settings to insure the best job. For easier reading, solid columns of numerals can be broken by a space at intervals.

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Be sure that white paper (not offset master stock) is used. Lined form stock is usually unsatisfactory, because the gray lines come out black in the printed copy and make the tabulation difficult to read.

Some report authors are not fortunate enough to be able to help the programer plan the printout format, and must make other arrangements for headings and groupings. By far the easiest method of providing headings is to ask the publications group (or a co-operative draftsman) to prepare an acetate overlay showing headings, rulings, etc. The beautiful part of this technique is that the overlay can be used repeatedly for other tables in the same series.

Information that can be covered before attaching overlay

Printout Sheets

Register Mark

Acetate Overlay

Don't plan large sheets that require drastic photographic re-
duction. When the printout letters are largest, they are most apt to
be distinguishable.

Some administrative information or identifying data may be
necessary on each printout sheet, but this type of material may be
set in a corner at the top of the sheet and removed before publica-
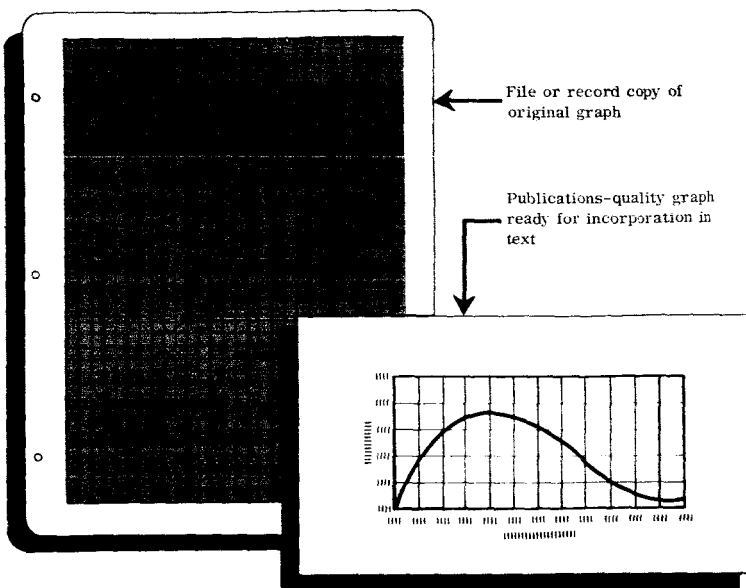tion.

Chances are you will have to handle the printout data while
writing and arranging the summary and other tabulations. But be
careful--the camera can see smudges, notes, check marks, and
some types of creases. If you must mark the sheets, use a light blue
pencil lightly, and do not attempt to erase.

GRAPHS

Since it must be assumed that your reader is innocent of the
profound implications of some of your data, it's necessary to
literally "draw him a picture." Of course that picture is usually a
graph of some kind--the kind that is especially sanitized, simplified,
amplified, annotated, and explained in the light of the text. Don't
expect to find a secret ritual or magic formula for designing exotic
graphs in the next few pages--the design and subject matter are your
concern--we can only help you present what you already know.

There comes a point in any researcher's life when he must
cease to think about data, and consider his reader. Ordinarily, this
point comes when the data must be presented to the reader. Your
cause for concern begins as you outline your paper, for your text
should be inextricably interwoven with your data presentations. Di-
rect reference to the graphic matter and its display adjacent to the
discussion are fully as important as easily understood graphs. In
fact, if this technique of distributing related illustrations throughout
the report is followed carefully, less explanation, annotation, and
cross referencing are needed. Besides, your reader will be de-
lighted!

The most natural question you may ask is--"Why all this fuss
about graphs? I've been working with graphs since first-year alge-
bra--so what's so different about graphs in a report?" Good

File or record copy of
original graph

Publications-quality graph
ready for incorporation in
text

thoughts, and pretty typical of the subject matter expert. But imagine what your reader is like--he does not have all the insight into your research that you have--he is bothered by things he does not comprehend--and does not have time to deduce subtle conclusions from seemingly uncorrelated data. To get through to him, you must make it graphically obvious, then explain in words the what, why, how, or where as necessary.

What Goes on a Graph?

What indeed but the data and enough information to make it intelligible? Absolutely right--except that graphs of data for informal, file, project, or other uses are read in a different context from publication graphs. The disembodied graph that goes in your file must show things such as company name, address, project name or number, investigator's name, dates, title, notes, (frequently) mathematical formulas, and sometimes sectional views or schematics. Consider the publication graph: Its identity (except for

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a caption) has been established; company name, address, report
title, author, and publication date appear on the cover and title page
of the report; the caption describes (and discusses) the graph and
its implications; the supporting text fully explains any mathematical
derivations or relationships; and other figures adequately show and
relate necessary schematics, sections, or auxiliary views. This
makes the publications graph a slightly different breed: somewhat
austere, but designed to do a particular job in a particular context.

How Much on a Graph?

This is one of those good questions for which there is no valid
answer--except the universal admonition of the graphics experts;
"don't crowd it." The problem is twofold. First, too many curves or
points tend to confuse rather than enlighten the reader. Then, even
the best drawings have a way of becoming degraded in reproduc-
tion.*

Your reader's interest goes just so far--usually about as far
as finding a trend or comparison. If he needs accuracy greater than
a couple of places, it's best to present a table, rather than a graph.
But if a graph is the thing for a particular job it should be just
complete enough to tell the story when read and related to the text.

It's probably worthwhile to talk with your draftsman about
practical limits on the density of information in your particular
organization. Generally, though it's almost impossible to dis-
tinguish between more than six different curve lines and types of
points. If one of your busier readers were queried on this point,
you'd probably get upper limits of about four different curves and
sets of points.

One of the things that makes even a simple graph look for-
bidding is too finely divided paper. Of course grid divisions should
not exceed the accuracy of the graph, but perhaps you should

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*Even if the complicated presentation stands up OK in the first printing,
it can still lose ground later when reduced to microfilm. And it's the fate of
every good report to eventually exist only in the form of microfilm or microfiche.

seriously question just how much grid is actually needed in order to interpret the graph. If yours are similar to most scientific presentations, 1/4-to 1/2-inch grids are ordinarily sufficient.

Some scientists even want you to leave all grid lines off the graph. They would rather have "tick" marks at the graph frame and draw their own grid lines. This is perfectly acceptable, but should be done with the same sort of discretion you use in choosing scale, selecting representative examples, and summarizing.
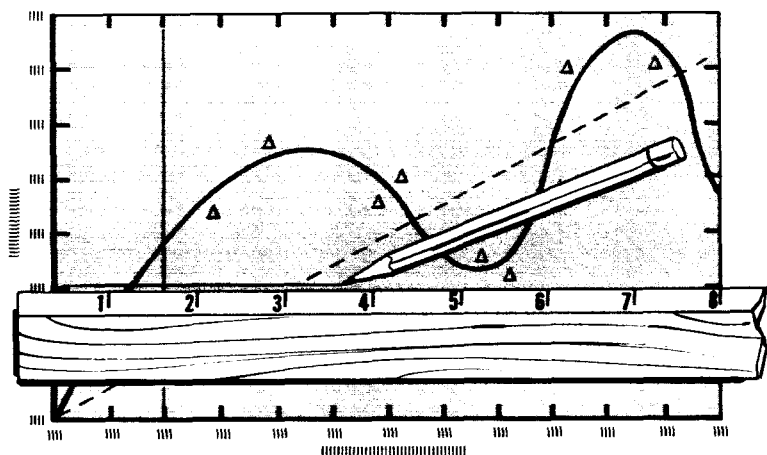
Remember that the ticks should always be used on all four sides of the graph frame.

Of course, there is always the general curve, that simply illustrates a relationship:
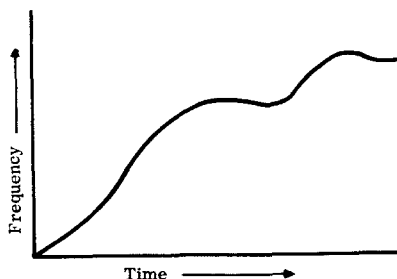

Obviously, neither grid nor ticks are called for.

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Comparable Graphs

It's often necessary to string several graphs in a series to make comparisons easy. This sounds beautifully simple, and can be so in truth if you make sure that each of the graphs in the series to be compared is identical in labeling, scale-divisions, and coding. Early planning and consultation with your draftsman or illustrator will help you to bring this trick off with little bother.

Six curves can be read for comparison in one page opening.
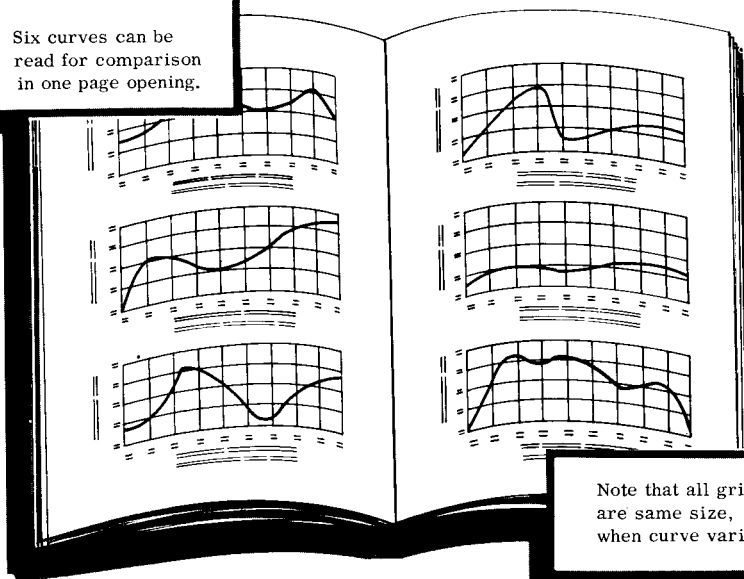
Note that all grids are same size, even when curve varies.

Slicing and Summarizing

Even a truckload of raw data has no meaning for an uninitiated report reader. You may hesitate to make gross reinterpretations of data that (to you) may be slightly ambiguous. But don't hesitate to make your interpretation clear to the reader. This is sometimes best done with simplified graphic summaries or extracts that are

specially drawn in selected scale to demonstrate a particular point. If you have some doubts about leading the poor reader about by the nose, you can always include as much as is necessary of the "original" curves for the skeptics.

Raw, highly detailed, or particularly voluminous data that must be shown should usually be relegated to an appendix and carefully referenced when presenting your summaries and predigested data and analyses.

Typical results extrapolated from voluminous data
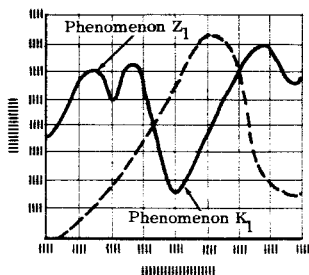
Author's Notes and Data

The 57 Varieties

Presenting data is not simply plotting a cumulative curve for a trend-conscious audience. Things can, and frequently do, become very complex when committed to two coordinates. This means you'll probably be putting together graphs of all varieties, and upon occasion inventing new breeds for that particularly thorny job. Although your new breeds of graph may be supremely logical and contain all the interrelated data you want to present, your poor benighted reader may not get your message. He typically thinks in terms of the classic varieties of graphs, and is totally lost when asked to interpret a new variety.

All this boils down to one admonition: If you must invent a new type of graph to present your data, make it easily understood.

But will he really understand? He will if you make it plain. No presentation can be understood if ordinate and abscissa are not
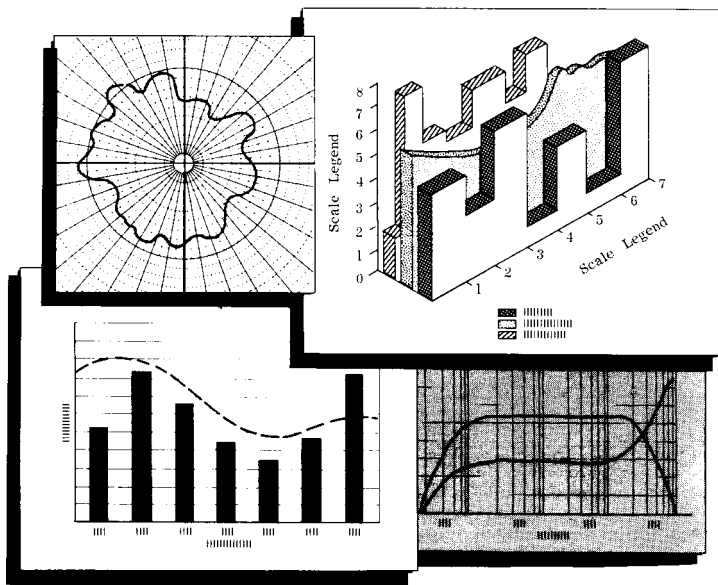
- fully identified, caption clearly written, and curves identified. It's really better to over explain slightly than have to answer correspondence about unclear points.

CHECKING THE RESULTS

No job of data presentation--graphic or tabular--is complete before a thorough proofreading and inspection. You, as the author are in a unique position to determine that all your presentations say exactly what you want the reader to know. No proofreader, no matter how skilled, could make this determination. Before any report leaves your office it's well worth your while to carefully check each table and graph, individually and in context with the report, for both numberical accuracy and emphasis.

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